San Joaquin Formation as a Potential Alternative for Disposal of the Elk Hills Power Plant Wastewater

Introduction

An examination of the Pliocene San Joaquin Formation as an alternative to the Tulare Formation for disposal of the wastewater from the Elk Hills Power Plant examines historic and current injection characteristics in the San Joaquin, the potential surface disturbance and other environmental impacts from a San Joaquin disposal well program, and the impacts on production to wells producing from the Dry Gas Zone.

The San Joaquin Formation contains predominantly mudstone and claystone with interbedded lenses of very fine grain unconsolidated sand. Sand intervals of the San Joaquin Formation produce gas on the updip areas of Elk Hills and constitute the Dry Gas Zone, one of the productive intervals at the Elk Hills Field. At the location of the proposed disposal wells in Sections 1B and 2B, sands within the San Joaquin Formation are below the gas-water contact of the Dry Gas Zone.

Injection Characteristics into the San Joaquin Formation

Elk Hills has a small disposal project into the San Joaquin Formation in Sections 25S, 26S, and 27S area. The project contains nine total wells, with three currently actively disposing of produced water. Average injection over the life of the wells is 1,400 barrels per day (see Attachment 1). Pumping is required to dispose of the water in the wells. A study of Elk Hills reservoir quality indicates that the 25S, 26S and 27S area may be more coarse grained and have better porosity than in the 1B and 2B area (Maher et al., 1975, Petroleum Geology of Naval Petroleum Reserve No. 1, Elk Hills, Kern County, California: USGS Professional Paper 912; Plate 24). Therefore, injection into the San Joaquin Formation in Section 1B and 2B may be less than 1,400 barrels per day.

In order to handle the expected wastewater disposal of 15,000 barrels per day of the Elk Hills Power Plant, approximately 10 disposal wells may be necessary to be drilled and completed in San Joaquin Formation. Therefore, the Tulare Formation is the best interval for the Elk Hills Power Plant wastewater disposal because only four wells will be required. In addition, the south half of Section 2B is part of the Elk Hills Conservation Area (CA). A perpetual conservation easement with the California Department of Fish and Wildlife was fully executed in January 2013. The easement states that a maximum allowable disturbance for lands included in the CA is 10% net per quarter section (16 acres). To date, 1.55 acres have been disturbed in the SW quarter and 8.31 acres disturbed in the SE quarter of 2B from the construction of roads and well pads.

Environmental Impacts of San Joaquin Disposal Wells

An average disposal well pad is about 1 acre in size. For a 10 well San Joaquin Formation disposal program about 10 acres of surface disturbance would be required. Additional disturbance would be required for access roads and pipelines. This compares to only 4 acres of disturbance for a Tulare disposal program.

Other environmental impacts may include increased air emissions from the additional horsepower

necessary for disposal into the San Joaquin Formation.

Impacts on DGZ Operations

Gas wells producing from the Dry Gas Zone of the San Joaquin Formation are flowing wells and produce gas and water without artificial lift. Attempts to use down-hole pumps to increase productivity have failed because loose, fine grained sand from the formation causes damage to the pump mechanism.

Disposal of the Elk Hills Power Plant wastewater into the San Joaquin Formation would likely have an adverse affect on the production of gas from the Dry Gas Zone. Direction of water flow in the formation would be from the disposal site toward the updip producing wells. The introduction of the wastewater would result in higher formation pressure within the sands of the San Joaquin Formation, and an increase flow of water toward the producing wells. At the site of producing wells, additional water at higher pressure would overwhelm the gas production and result in suppressing or eliminating gas production. Pumping to remove excess water in the wells is not feasible due to the presence of loose, fine grained formation sand that will cause damage to the pump.

Conclusion

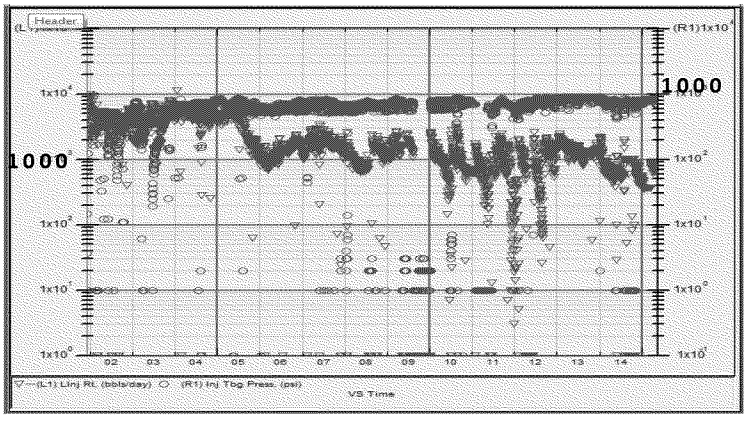
The San Joaquin Formation has low injectivity based on well performance from a nearby disposal project. As many as 10 disposal wells would be required to dispose of the Elk Hills Power Plant wastewater. Drilling this many wells would have a significant surface disturbance across the disposal project area. Disposal of wastewater into the San Joaquin Formation will likely have an adverse effect on updip gas wells that produce from the same intervals and may result in reduced recover of natural gas and increased water production.

Disposal into the Tulare Formation is a better alternative to the San Joaquin Formation. Fewer wells will be needed to dispose of the wastewater. The Tulare Formation will take the wastewater on a vacuum, and the disposed wastewater will not interfere with any producing reservoir within the Elk Hills Field.

Attachment 1: Elk Hills Unit

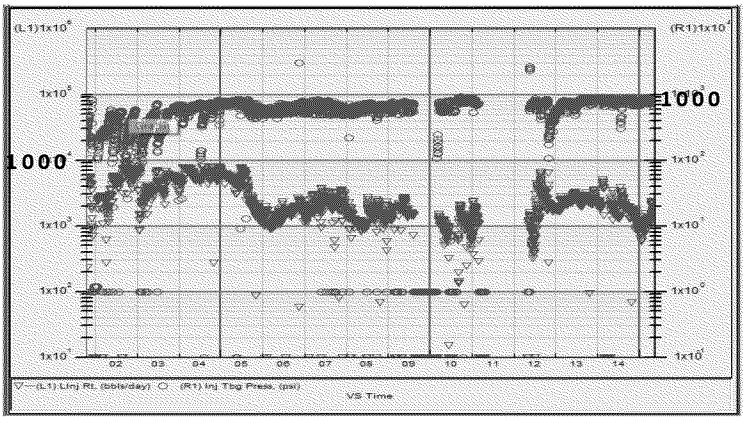
San Joaquin formation Injection

381WD-26S



Wellhead Pressure, psig Injection Rate, bwpd

5-321WD-26S



43WD-27S